

[0031]

What is claimed is:

1. A method of consolidating a subterranean zone penetrated by a well bore comprising the steps of:

(a) introducing a brine preflush containing a cationic surfactant into said subterranean zone around and adjacent to said well bore;

(b) introducing a hardenable resin composition into said subterranean zone around and adjacent to said well bore, said hardenable resin composition comprising a furan liquid resin mixture, a solvent, an organosilane coupling agent and an acid catalyst;

(c) introducing a brine overflush containing a cationic surfactant into said subterranean zone to displace the resin composition from the pore space in said subterranean zone; and

(d) allowing said hardenable resin composition to harden and form said subterranean zone around and adjacent to said well bore into a consolidated permeable mass.

2. The method of claim 1 wherein said brine preflush and overflush are sodium chloride brines.

3. The method of claim 2 wherein said sodium chloride is present in said brine preflush and overflush in an amount of about 15% by weight of said brine preflush and overflush.

4. The method of claim 1 wherein said cationic surfactant in said brine preflush and overflush is selected from the group consisting of ethoxylated nonyl phenol phosphate ester, C₁₂

to C₂₂ alkyl phosphonate surfactants, and mixtures of one or more cationic surfactants and one or more non-ionic surfactants.

5. The method of claim 1 wherein said cationic surfactant in said brine preflush and overflush is a C₁₂ - C₂₂ alkyl phosphonate surfactant.

6. The method of claim 1 wherein said cationic surfactant is present in said brine preflush and overflush in an amount in the range of from about 0.01% to about 3% by weight of said preflush and overflush.

7. The method of claim 1 wherein said furan liquid resin mixture comprises a 2-furanmethanol homopolymer present in said mixture in an amount in the range of from about 55% to about 60% by weight thereof and furfuryl alcohol present in said mixture in an amount in the range of from about 40% to about 45% by weight thereof.

8. The method of claim 1 wherein said furan liquid resin mixture is present in said hardenable resin composition in an amount in the range of from about 20% to about 60% by weight thereof.

9. The method of claim 1 wherein said solvent is selected from the group consisting of furfuryl acetate, C₁ - C₈ alkyl acetates, 2-butoxy ethanol, diethylene glycol methyl ether, diethylene glycol dimethyl ether, and dipropylene glycol methyl ether.

10. The method of claim 1 wherein said solvent is furfuryl acetate.

11. The method of claim 1 wherein said solvent is present in said hardenable resin composition in an amount in the range of from about 40% to about 80% by weight thereof.

12. The method of claim 1 wherein said organosilane coupling agent is selected from the group consisting of N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane and n-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane.

13. The method of claim 1 wherein said organosilane coupling agent is N-2-(aminoethyl)-3-aminopropyltrimethoxysilane.

14. The method of claim 1 wherein said organosilane coupling agent is present in said hardenable resin composition in an amount in the range of from about 0.1% to about 2% by weight thereof.

15. The method of claim 1 wherein said acid catalyst is selected from the group consisting of salicylic acid, ethylenediaminetriacetic acid, benzoic acid, oxalic acid, maleic acid, alkyl benzenesulfonic acids and salts thereof.

16. The method of claim 1 wherein said acid catalyst is an alkyl benzenesulfonic acid.

17. The method of claim 1 wherein said acid catalyst is present in said hardenable resin composition in an amount in the range of from about 0.01% to about 10% by weight thereof.

18. The method of claim 1 wherein said brine preflush is introduced into said subterranean zone at a pressure below the fracture pressure of said zone and a rate in the range of from about 0.1 to about 5 barrels per minute until a total volume of at least about 20 gallons of said brine per foot of said well bore interval in said subterranean zone has been introduced.

19. The method of claim 1 wherein said brine overflush is introduced into said subterranean zone at a pressure below the fracture pressure of said zone and at a rate in the range of from about 0.1 to about 5 barrels per minute until a total volume of about 3 times the volume of said preflush has been introduced.

20. A method of consolidating a subterranean zone penetrated by a well bore comprising the steps of:

(a) introducing a brine preflush containing a cationic surfactant into said subterranean zone around and adjacent to said well bore;

(b) introducing a hardenable resin composition into said subterranean zone around and adjacent to said well bore, said hardenable resin composition comprising a furan liquid resin mixture, a solvent, an organosilane coupling agent and an acid catalyst;

(c) circulating a clean-up brine in said well bore penetrating said subterranean zone to remove hardenable resin composition therefrom without significantly disturbing the hardenable resin composition in said subterranean zone;

(d) allowing said hardenable resin composition to harden in said subterranean zone whereby said subterranean zone around and adjacent to said well bore including in the pore spaces thereof is consolidated into a solid impermeable mass; and then

(e) fracturing said subterranean zone and placing particulate proppant material therein to provide flow channels through said solid impermeable mass.

21. The method of claim 20 wherein said brine preflush and said clean-up brine are sodium chloride brines.

22. The method of claim 21 wherein said sodium chloride is present in said brine preflush and said clean-up brine in an amount of about 15% by weight of said brine preflush and said clean-up brine.

23. The method of claim 20 wherein said cationic surfactant in said brine preflush and said clean-up brine is selected from the group consisting of ethoxylated nonyl phenol phosphate ester, C₁₂ to C₂₂ alkyl phosphonate surfactants, and mixtures of one or more cationic surfactants and one or more non-ionic surfactants.

24. The method of claim 20 wherein said cationic surfactant in said brine preflush and said clean-up brine is a C₁₂ – C₂₂ alkyl phosphonate surfactant.

25. The method of claim 20 wherein said cationic surfactant is present in said brine preflush and said clean-up brine in an amount in the range of from about 0.01% to about 3% by weight of said brine preflush and said clean-up brine.

26. The method of claim 20 wherein said furan liquid resin mixture comprises a 2-furanmethanol homopolymer present in said mixture in an amount in the range of from about 55% to about 60% by weight thereof and furfuryl alcohol present in said mixture in an amount in the range of from about 40% to about 45% by weight thereof.

27. The method of claim 20 wherein said furan liquid resin mixture is present in said hardenable resin composition in an amount in the range of from about 20% to about 60% by weight thereof.

28. The method of claim 20 wherein said solvent is selected from the group consisting of furfuryl acetate, C₁ - C₈ alkyl acetates, 2-butoxy ethanol, diethylene glycol methyl ether, diethylene glycol dimethyl ether, and dipropylene glycol methyl ether.

29. The method of claim 20 wherein said solvent is furfuryl acetate.

30. The method of claim 20 wherein said solvent is present in said hardenable resin composition in an amount in the range of from about 40% to about 80% by weight thereof.

31. The method of claim 20 wherein said organosilane coupling agent is selected from the group consisting of N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane and n-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane.

32. The method of claim 20 wherein said organosilane coupling agent is N-2-(aminoethyl)-3-aminopropyltrimethoxysilane.

33. The method of claim 20 wherein said organosilane coupling agent is present in said hardenable resin composition in an amount in the range of from about 0.1% to about 2% by weight thereof.

34. The method of claim 20 wherein said acid catalyst is selected from the group consisting of salicylic acid, ethylenediaminetriacetic acid, benzoic acid, oxalic acid, maleic acid, alkyl benzenesulfonic acids and salts thereof.

35. The method of claim 20 wherein said acid catalyst is an alkyl benzenesulfonic acid.

36. The method of claim 20 wherein said acid catalyst is present in said hardenable resin composition in an amount in the range of from about 0.01% to about 10% by weight thereof.

37. The method of claim 20 wherein said brine preflush is introduced into said subterranean zone at a pressure below the fracture pressure of said zone and a rate in the range of from about 0.01 to about 5 barrels per minute until a total volume of at least about 20 gallons of said brine per foot of said subterranean zone has been introduced.

38. A hardenable resin composition comprising:

a furan liquid resin mixture comprising a 2-furanmethonal homopolymer and furfuryl alcohol;

an organosilane coupling agent; and

an acid catalyst.

39. The composition of claim 38 wherein said 2-furanmethonal homopolymer is present in said furan liquid resin mixture in an amount in the range of from about 55% to about 60% by weight thereof and said furfuryl alcohol is present in said mixture in an amount in the range of from about 40% to about 45% by weight thereof.

40. The composition of claim 38 wherein said furan liquid resin mixture is present in said hardenable resin composition in an amount in the range of from about 20% to about 60% by weight thereof.

41. The composition of claim 38 wherein said solvent is selected from the group consisting of furfuryl acetate, C₁ - C₈ alkyl acetates, 2-butoxy ethanol, diethylene glycol methyl ether, diethylene glycol dimethyl ether, and dipropylene glycol methyl ether.

42. The composition of claim 38 wherein said solvent is furfuryl acetate.

43. The composition of claim 38 wherein said solvent is present in said hardenable resin composition in an amount in the range of from about 40% to about 80% by weight thereof.

44. The composition of claim 38 wherein said organosilane coupling agent is selected from the group consisting of N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane and n-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane.

45. The composition of claim 38 wherein said organosilane coupling agent is N-2-(aminoethyl)-3-aminopropyltrimethoxysilane.

46. The composition of claim 38 wherein said organosilane coupling agent is present in said hardenable resin composition in an amount in the range of from about 0.1% to about 2% by weight thereof.

47. The composition of claim 38 wherein said acid catalyst is selected from the group consisting of salicylic acid, ethylenediaminetriacetic acid, benzoic acid, oxalic acid, maleic acid, alkyl benzenesulfonic acid and salts thereof.

48. The composition of claim 35 wherein said acid catalyst is an alkyl benzenesulfonic acid.

49. The composition of claim 38 wherein said acid catalyst is present in said hardenable resin composition in an amount in the range of from about 0.01% to about 10% by weight thereof.